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(54) Title: WINDING OF ELECTRIC CABLE IN ELECTRIC MACHINES

(54) Titre: BOBINAGE DE CABLE ELECTRIQUE DANS DES MACHINES ELECTRIQUES

(57) Abstract

Equipment for achieving a winding of electric cable (22) in an electric machine with at least one laminated core (54) comprises at least one manipulator adapted to operate an associated cable feeder (24, 28) to feed cable at an intended radial position into a winding slot at one side of the laminated core, and at least one other manipulator adapted to apply its associated cable feeder (26, 30) to the corresponding radial position on the opposite side of the core in order to pull the fed-in cable axially through the winding slot. In a method for achieving a winding of electric cable in an electric machine comprising a laminated core, the electric cable is pulled axially through the winding slot in the laminated core at the intended radial positions in the slots.

(57) Abrégé

Un matériel destiné à effectuer un bobinage de câble électrique (22) dans une machine électrique présentant au moins un noyau stratifié (54) comprend au moins un manipulateur adapté pour faire fonctionner une chargeuse associée (24, 28) de câble destinée à acheminer un câble au niveau d'une position radiale voulue dans une fente de bobine située d'un côté du noyau stratifié, ainsi qu'au moins un autre manipulateur adapté pour appliquer sa chargeuse associée (26, 30) de câble dans une position radiale correspondante sur l'autre côté du noyau, afin de tirer le câble acheminé axialement à travers la fente de bobinage. Dans un procédé d'obtention d'un bobinage de câble électrique dans une machine électrique contenant un noyau stratifié, le câble électrique est tiré axialement à travers la fente de bobinage dans le noyau stratifié au niveau des positions radiales voulues dans les fentes.

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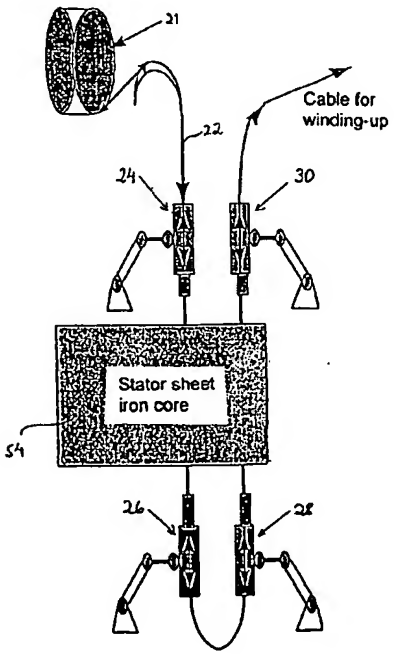

(57) Abstract: Equipment for achieving a winding of electric cable (22) in an electric machine with at least one laminated core (54) comprises at least one manipulator adapted to operate an associated cable feeder (24, 28) to feed cable at an intended radial position into a winding slot at one side of the laminated core, and at least one other manipulator adapted to apply its associated cable feeder (26, 30) to the corresponding radial position on the opposite side of the core in order to pull the fed-in cable axially through the winding slot. In a method for achieving a winding of electric cable in an electric machine comprising a laminated core, the electric cable is pulled axially through the winding slot in the laminated core at the intended radial positions in the slots.

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WINDING OF ELECTRIC CABLE IN ELECTRIC MACHINES

Technical field

The present invention relates to equipment for achieving a winding of electric cable in an electric machine, comprising a sheet iron core, and to such a winding method.

Background

In certain types of electric machines, i.e. of the types described in WO97/45919 and WO97/45847, the winding comprises an electric cable. It is hereby desirable to use long, continuous lengths of cable in order to obtain as few cable joints as possible. Thus, as a result of this technique a continuous cable forms a plurality of winding turns, in contrast to corresponding conventional technique, so that winding can be positioned in slots in steel cores, whereby the machine windings are manufactured by means of a time-consuming operation which involves positioning rigid rails or rods in the winding slots, which rails or slots each constitute only a part of a winding turn. Furthermore, in the present type of machines, cable having stepped insulation is frequently used, i.e. winding turns that are located deepest down in the winding slots display the thickest insulation, whereas the insulation of the winding turns gradually tapers off outwardly simultaneously with the width of the slot decreasing outwardly to a corresponding extent so as to contribute to secure the winding in the slot. Thus, in this type of machines it is not possible to position the cable radially in the winding slots in the same way as when machines are wound in the conventional manner, which involves using straight winding slots.

The cable for the high voltages occurring in this connection, for example in the voltage range of 72-800 kV, is furthermore relatively stiff and therefore difficult to align manually without means of assistance. The cable is also far too heavy to handle manually. Mechanical means of assistance are thus necessary to handle the cable.

Summary of the invention

The object of the invention is to propose equipment well suited for handling heavy electric cable in large lengths in order to achieve windings of the electric cable in the above-mentioned type of machine, according to a completely new technique, for the production of electric windings, and to suggest a corresponding winding method.

This object is achieved by means of equipment and a method of the kind described in the introductory part of the description, having characteristic features described in the preamble to claims 1 and 22, respectively.

Thus, with the present invention, a piece of equipment is achieved and a method is suggested for producing the windings of the machines by drawing the cable axially through the steel core of the machine at the intended radial position of the cable in the relevant winding slot in the core. The invention enables the use of very long continuous cable lengths, which are typically hundreds of metres long forming a (normally large) plurality of winding turns. The number of cable joints is hereby reduced. Further, a considerable saving of time is achieved with the winding method, while at the same eliminating wear of personnel.

According to advantageous embodiments of the equipment, according to the invention, the cable feeder comprises a motor-driven, endless feeder belt suitably comprising one or several cog belts or V-belts or a roller chain having rubber-covered carriers, with which the cable is intended to make contact. This ensures sufficient friction against the cable in order for the cable to be carried along with the feeder belt in a reliable way during operation thereof. To additionally increase reliability in this regard, according to other advantageous embodiments of the equipment according to the invention, backing rollers are positioned opposite to the feeder belt in order to press the cable against the feeder belt so that it is securely positioned, the cable feeder alternatively comprising two feeder belts opposite to each other, between which the cable is intended to be applied.

According to another advantageous embodiment of the equipment according to the invention, the distance between the backing rollers and the feeder belt, or between two feeder belts positioned opposite to each other, is variable for adjustment to different cable diameters. A so-called forerunner in the form of a cable, rope or the like with a smaller diameter, typically 20-30 mm, is often used. The forerunner is secured at the end of the conducting core of the cable by means of a special clamping sleeve after removing part of the insulation, and the cable end is often cone-shaped to facilitate passage in confined spaces. Because the distance between the backing rollers and the feeder belt, or between two feeder belts positioned opposite to each other, is variable, the distance can be adjusted to the dimension of this forerunner as well.

According to a further advantageous embodiment of the equipment according to the invention, the cable feeder comprises guide rollers at the ends of the feeder belts in order to guide the cable onto the feeder belt. The distance between two adja-

cently positioned guide rollers is also adjustable and can be adjusted to different cable diameters.

According to another advantageous embodiment of the equipment according to the invention, the cable feeder is equipped with a guiding tube in order to guide the cable towards the intended leading-in position in the relevant winding slot in the core of the electric machine. While winding a stator, for example, the guiding tube of the feeder is placed by means of the manipulator straight over the actual position of the stator slot in question and perpendicular to the stator sheet. With the help of the manipulator, located at the opposite side of the stator steel core, the feeder having guiding tubes is fixed immediately under the actual leading-in position in the stator slot in order to pull the cable axially through the stator steel core perpendicular thereto, thus minimising wear of the cable.

According to still another advantageous embodiment of the equipment according to the invention, the guide tube comprises two tube halves, pivotally joined together along an axis extending parallel to the tube. In this way, thus, the tube can be opened by means of the tube halves pivoting apart enabling the cable to be fed into the guiding tube perpendicular to the longitudinal direction of the feeder belt.

According to yet another embodiment of the equipment according to the invention, a motor-driven articulated-arm arrangement is adapted to fold the guiding tube under the feeder belt, if required. With a folded-in guiding tube, cable management is facilitated, especially as regards the design of cable arches in the coil-end area.

According to another advantageous embodiment of the equipment according to the invention, the manipulator comprises an automatic device or a robot, which is modularised so as to adjust in simple fashion to installation of cables having different dimensions in electric machines. The robot can also be adjusted for different purposes at the site of installation. The same robot can thus be used for laying steel as well as winding of an electric machine.

According to still another advantageous embodiment of the equipment according to the invention, the manipulator with the cable feeder, the guiding tube and associated guiding and other peripheral equipment is mounted on a carrier car. In this way, the equipment can be moved in a comfortable manner.

Winding up of wire, cable and the like is known per se. During such winding up, the wound-on material, for example a cable, is twisted, that is, torsionally rotated, where one turn of winding provides one turn of twist. When winding cable in, for example, the stator of rotating electric machines, such winding up is not suitable, especially when working with long cables. According to an advantageous embodiment of the

equipment according to the invention, therefore, a winding-up device is designed for winding up cable in the form of a horizontal figure of eight. In this way, twisting of the cable is eliminated.

The relatively stiff and heavy cable must be straightened in connection with being pulled from the storage drum, and for that reason, according to an advantageous embodiment of the equipment according to the invention, a straightening device is arranged between the storage drum and the cable feeder for straightening the cable.

According to an advantageous embodiment of the method according to the invention, the manipulators are controlled to form, with their cable feeders, coil arches with a mushroom-like geometrical shape to increase the radius of curvature of the cable. The cable used is bendable, by which is preferably meant that a radius of curvature of 8-12 times the cable diameter should be aimed at. In normal cases, the cable is bent in an arch between two stator slots. If this leads to a smaller radius of curvature than the preferred one, this may result in the insulating properties of the cable being jeopardised. With the method according to the invention, this problem is thus solved by increasing the radius of curvature of the arch. An additional advantage of this shape of the coil arch is achieved when bracing the coil end, since this geometry enables a more flexible and simple movement of the cable in a radial direction.

According to a further advantageous embodiment of the method according to the invention, the manipulators are controlled to execute long winding stages in order to lay the cable in large, temporary coil arches by means of the cable feeders, which coil arches serve as intermediate storage for the cable during winding. Thus, as much cable as possible is supplied at one sweep by laying up the cable in arches outside the stator. In this way, a cable magazine is created, which enables the cable to be continuously passed on in new slots, in a forward direction in the stator. This also makes the cable more protected against damage, which may otherwise occur when handling the cable on the floor. Such enlarged arch ends also make it possible to operate in parallel, during winding, at several locations on the stator with several feeders at the same time, which, of course, saves time.

Description of the drawings

To explain the invention in greater detail, embodiments of the invention, chosen as examples, will now be described with reference to the accompanying drawings, wherein

Figure 1 shows the principle of the arrangement, in one embodiment, of the equipment according to the invention, intended for winding of heavy cable,

Figure 2 shows an example of a manipulator suited for use in the equipment according to Figure 1, in the form of an industrial robot,

Figure 3 shows in side view an embodiment of the cable feeder in the equipment according to Figure 1,

Figures 4-6 show various views of the cable feeder according to the corresponding arrows in Figure 3,

Figure 7 shows an example of a geometrical shape of the coil end in a stator winding of cable,

Figure 8 illustrates schematically an embodiment of an automatic device or a robot suited for use as a manipulator in the equipment according to the invention, and

Figure 9 shows an example of part of a winding-up device suited for use when manufacturing stator winding of cable.

Description of embodiments

Figure 1 shows fundamental arrangement of the equipment according to the invention according to an embodiment for winding of heavy cable 22. The equipment comprises four manipulators, each one provided with specially-built cable feeders with guiding tubes mounted thereon.

The manipulators may advantageously be in the form of industrial robots, for example robots marketed under the designation ABB IRB 6400 with six movement axes, Axis 1, Axis 2, Axis 3, Axis 4, Axis 5, Axis 6, as illustrated in Figure 2, the cable feeders being mounted in the tool attachments of the robots (cf. also the description of Figure 8 below).

The cable feeder 24 in Figure 1 pulls the cable 22 from a storage drum 21. The cable 22 must be straightened in connection with being pulled from the storage drum 21, and for that reason a straightening device (not shown in the figures) should be placed between the storage drum and the length-measuring equipment which normally occurs for measuring the cable lengths. In case of a large distance between the storage drum 21 and the cable feeder 24, additional floor-mounted feeders may be necessary (also not shown in the figure.)

With the aid of the manipulator, the feeder 24 with its guiding tube, which will be explained in more detail below, is placed straight above the actual position in the stator slot and perpendicular to the stator steel core 54 of the machine.

By means of its manipulator, the cable feeder 26 with its guiding tube is placed just below the actual position in the slot in the stator core on the opposite side of the stator steel core 54. With this cable feeder 26, the cable is pulled axially through the stator steel core 54, perpendicular thereto.

The manipulators are controlled to form, with their cable feeders 26, 28, separately or jointly, a suitable cable arch prior to feeding into the next slot by movements in space, while at the same time cable is fed forwards. During this operation, it may be suitable to place the guiding tube in a folded-in position under the feeder, as will be described in more detail below.

When manufacturing this cable arch, the cable is thus bent. A radius of curvature of 8-12 times the cable diameter should preferably be aimed at. In case a lower radius of curvature of the cable arch than the preferred one should be attained, the insulating properties of the cable may be jeopardised. To eliminate this problem, the geometrical shape of the coil arch may be changed into a mushroom-like geometry 56, as illustrated in Figure 7. In this way, a significant increase of the radius of curvature is achieved, from 276 mm to 427.4 mm in the example shown (cf. arches 58 and 56 in the figure). In this way, the requirements for the radius of curvature are normally fulfilled. Additional advantages of this geometry are achieved when bracing the coil end since this geometry enables a more flexible and simpler movement of cable in a radial direction.

By means of its manipulator, the cable feeder 28 with its guiding tube is then placed straight below the actual position in the next slot in the stator core and the cable feeder 28 threads the cable perpendicular to the stator steel core 54.

Further, by means of its manipulator, the cable feeder 30 with its guiding tube is placed straight above the actual position in the above-mentioned next stator slot on the opposite side of the stator steel core 54 just opposite the cable feeders 28 to again pull the cable axially through the stator steel core 54 in the opposite direction and perpendicular to the stator steel core 54 to minimise the cable wear.

The manipulators with their feeders 24, 26, 28, 30 remain in their set positions while the cable 32 is fed forward. The rates of feed and the torques are adapted by means of a common control system such that the cable feeders co-operate in a correct way.

Figure 3 shows a side view of one embodiment of a cable feeder. An endless feeder belt 01 is driven via two parallel axes 02 with common drive from a drive motor 03 (see Figure 4), possibly via a gearbox. The feeder belt 01 may comprise one or more cog belts or V-belts, or, alternatively, a roller chain provided with rubber-covered carriers formed to make good contact with the cable.

Above the feeder belt 01, two backing rollers 04 are arranged to press the cable against the underlying feeder belt 01 so that the cable makes safe contact with the feeder belt, such that the cable is carried along by the feeder belt, in a reliable manner, during movement thereof. The distance between the backing rollers 04 and the feeder belt 01 is automatically adjustable in at least two positions to adapt to the diameter of the forerunner and the cable. This adjustment is achieved with the aid of a two-step linear motor 05, for example consisting of two built-together pneumatic or hydraulic cylinders, linked together via toggle joints 06. To ensure parallel movement of the backing rollers 04, these are interconnected by means of toothed segments 07.

An alternative embodiment comprises replacing the backing rollers with an additional feeder belt, placed opposite to the feeder belt 01, which is adjustable in a similar way as the backing rollers. This second feeder belt may be provided with its own drive equipment, or, alternatively, lack such equipment.

Perpendicular to the backing rollers 04 of the feeder belt 01, outside each end of the feeder belt 01, there are two guide pulleys 08, intended to guide the cable accurately on the feeder belt 01 (see also Figure 4). Feeding of cable into the feeder should be performed perpendicular to the longitudinal direction of the feeder belt 01. To this end, the two guide pulleys 08 on the "opening side" can be manually folded to open for the feeding of the cable. The distance between two adjacent guide pulleys 08 is adjustable to adapt to different cable diameters in the same way as the distance between the backing rollers 04 and the feeder belt 01.

The cable feeder is associated with a guiding tube 09, which is divided in the axial direction into two half tubes, retained by hinges 10 on the opposite side of the tube in relation to the cable feed side (cf. also Figure 6). In the extension of the centre line of the hinges 10, there is a flat bar 11 which is twisted 90° and connected to the openable part of the guiding tube 09, such that, when the flat bar 01 is turned in one direction, also the openable part of the guiding tube 09 is turned.

Opening of the guiding tube 09 through the influence of the twisted flat bar 11 occurs with a linear motor 12, which may be a pneumatic or hydraulic cylinder. The movable part of the linear motor 12 is provided with a fork-shaped carrier 13 designed to slide outside the twisted flat bar 11 (see Figure 4). During axial movement of this

carrier, the twisted flat bar 11 is influenced such that the openable part of the guiding tube is opened to enable a cable to be placed therein.

When the fork-shaped carrier 13 is driven in the opposite direction, the openable part of the guiding tube 09 is closed and the tube parts are locked to each other by means of a number of spring-actuated locking devices 14, which automatically lock the openable part of the guiding tube 09 when this tube is in the closed position (see Figure 4).

To enable folding of the guiding tube 09 under the feeder belt 01, the fork-shaped carrier 13 with the linear motor 12 is mechanically disengaged from the guiding tube 09 in the closed position thereof. With a folded guiding tube 09, the cable handling is facilitated, especially when shaping cable arches in the coil-end region.

Therefore, the guiding tube 09 is suspended from a shaft 15 such that the tube can be turned 90° and be placed under the feeder belt 01. The folding of the guiding tube 09 takes place by means of a linear motor 16, which may be a pneumatic or a hydraulic cylinder, connected to the guiding tube 09 via an articulated arm 17.

Feeder belt 01, backing rollers 04, guide pulleys 08, motors 03, 05, 16 and shaft 15 for suspension of the guiding tube 09 are mounted on a common stand 18 (see also Figure 5). This stand also comprises holes for attachment of the tool attachment of the manipulator.

Each manipulator must be individually movable during cable pulling in an electric machine. To this end, each manipulator with control cabinet and feeder belt mounted thereon, including hydraulic unit or air compressor and any other additional equipment, is suitably applied on a carrier car adapted for the purpose.

In electric machines of the kind referred to here, the stator sheets have such dimensions and shapes that manual laying, in addition to causing loss of time, would also cause strain injuries to the sheet layers. By using robots or automatic devices of the kind described below, handling becomes significantly more efficient. Further, when winding the stator with the cable in question, one robot of the described kind fits the cable in one end of the stator and another robot pulls the cable axially in the other end.

Figure 8 schematically illustrates a simple robot for in-situ manufacture of an electric machine. In Figure 8, the robot is illustrated as used for sheet laying of the stator. With a picking arm 32, which is movable on a beam 34, as illustrated by arrows in the figure, stator sheets are picked from storage 36 and are placed in position in the stator, at 38. The figure further shows a beam 40, which supports the beam 34, as well as a brace 42 for bracing the beams 34, 40. The automatic device shown is movable around the centre axis of the stator as the sheet-laying operation proceeds.

The automatic device or robot shown is modularised such that it may be used for machines of various sizes, for example by adding or removing arm segments, and, in addition, it is easily transportable. Further, the same robot or automatic device may be used for winding of the stator as well as for sheet laying, in which case the gripping arm, inter alia, must be modified between the two work operations. The robot or the automatic device may be used for manufacturing turbo-machines as well as hydroelectric machines.

Control data for the robots are obtained directly from the same computer program platform in which the calculations on the electric machine are made.

Figure 9 shows part of a winding-up device suited for use when manufacturing a stator winding of an electric cable. The winding-up device is designed such that winding up of the cable takes place in the form of a horizontal figure of eight, whereby no twisting of the cable is occurs.

The device comprises an elevated stand 44 for a car, which is movable in the X-, Y- and Z-directions on the stand. As is clear from the figure, the transverse movement is denoted by X, the longitudinal movement by Y, and the vertically adjustable movement by Z.

On the underside of the car there is a cable feeder, consisting of an openable funnel and guide means for the cable.

Below the stand, at floor level, two non-rotatable round drums 46, 48 are arranged with vertical centre axes. The drums 46, 48 are suspended from a device which makes possible rotation of the drums around an axis of rotation Y1-Y1, which is parallel to the Y-axis.

When starting the winding up, the free end of the cable is moved through the cable feeder and the funnel on the lowered car to the lower edge of one of the drums and is attached there. The other end of the cable is assumed to be fixed in slots in the stator body. The car is run up to the upper position, in Z-direction. Winding-up can now be started, whereby the car with cable is brought, via a control program, to move along the X- and Y-axes in a movement pattern in the form of a horizontal figure of eight.

After the winding-up operation is completed, the cable is lifted off the car, which is now in a lowered position. The car is run up to the upper position along the Z-axis and is moved in the X- and Y-directions to a parking position. Thereafter, the drums 46, 48 are rotated 180° around the Y1-Y1 axis, whereby the free end of the cable becomes accessible for further operation. When the cable is now pulled off the drums, it has no twisting.

CLAIMS

1. Equipment for achieving a winding of electric cable in an electric machine comprising at least one laminated core, **characterized** in that at least one manipulator is adapted to operate an associated cable feeder to feed cable at an intended radial position into a winding slot at one side of the laminated core, and in that at least one other manipulator is adapted to apply its associated cable feeder to the corresponding radial position on the opposite side of the core in order to pull the fed-in cable axially through the winding slot.

2. Equipment according to claim 1, **characterized** in that the cable feeder comprises a motor-driven, endless feeder belt, with which the cable is intended to make contact for feeding or pulling.

3. Equipment according to claim 2, **characterized** in that the feeder belt comprises one or more cog belts or V-belts.

4. Equipment according to claim 2, **characterized** in that the feeder belt comprises a roller chain with rubber-covered carriers, with which the cable is intended to make contact.

5. Equipment according to any of claims 2 to 4, **characterized** in that backing rollers are arranged opposite to the feeder belt to press the cable against the feeder belt to provide safe contact therewith.

6. Equipment according to any of claims 2 to 4, **characterized** in that the cable feeder comprises two oppositely positioned feeder belts, between which the cable is intended to be applied.

7. Equipment according to claim 5 or 6, **characterized** in that the distance between backing rollers and feeder belts, or between two oppositely positioned feeder belts, is variable to adjust to different cable diameters.

8. Equipment according to any of claims 2 to 7, **characterized** in that the cable feeder comprises guide pulleys, arranged at the ends of the feeder belt, for guiding the cable on the feeder belts.

9. Equipment according to any of the preceding claims, **characterized** in that the cable feeder is equipped with a guiding tube for guiding the cable towards the intended leading-in position in the winding slot in question in the core of the electric machine.

10. Equipment according to claim 9, **characterized** in that the guiding tube comprises two tube halves, pivotally joined together along an axis extending parallel to the tube.

11. Equipment according to claim 10, **characterized** in that motor-driven means are intended to pivot apart the tube halves so as to open the tube for introducing cable perpendicular to the longitudinal direction of the tube.

12. Equipment according to claim 10 or 11, **characterized** in that locking means are adapted to lock the tube halves of the guiding tube to each other in the closed position.

13. Equipment according to any of claims 9 to 12, **characterized** in that a motor-driven articulated-arm arrangement is adapted to fold the guiding tube under the feeder belt, if required.

14. Equipment according to any of the preceding claims, **characterized** in that the manipulator comprises an automatic device or a robot, which is modularised to adapt to mounting of cable of different dimensions in electric machines.

15. Equipment according to any of the preceding claims, **characterized** in that the manipulator with the cable feeder, the guiding tube and associated control and other peripheral equipment is mounted on a carrier car.

16. Equipment according to any of the preceding claims, **characterized** in that a winding-up device is designed for winding up cable in the form of a horizontal figure of eight.

17. Equipment according to claim 16, **characterized** in that the winding-up device comprises a raised stand, on which a car is movable in three perpendicular directions in order to be brought, during the winding-up procedure, to move in a path in the form

of a horizontal figure of eight and, after completed winding, be raised and brought to a parking position, and that, on the underside of the car, a cable feeder is arranged to move the free cable end, when the winding-up is started, to one of two non-rotatable drums having vertical axes and being suspended under the stand, which drums are pivotable around an axis perpendicular to the drum axes in order to make the free cable end accessible again after completed winding-up operation.

18. Equipment according to any of the preceding claims, **characterized** in that between the storage drum and the cable drum a straightening device is arranged for straightening the cable.

19. Equipment according to any of the preceding claims, **characterized** in that a length-measuring device is arranged for measuring the length of cable pulled from the storage drum.

20. Equipment according to any of the preceding claims, **characterized** in that the storage drum and the winding-up device are provided with raisable and lowerable backing rollers for capturing cable pulled from the storage drum during winding off.

21. Equipment according to claim 20, **characterized** in that the backing rollers, in their upper position, are arranged to be on a level with the centre axis of the drum.

22. A method for manufacturing a winding of electric cable in an electric machine comprising a laminated core, **characterized** in that the electric cable is pulled axially through winding slots in the laminated core at intended radial positions in the slots.

23. A method according to claim 22, wherein the winding is the stator winding of a rotating electric machine, **characterized** in that a first cable feeder is applied with its associated manipulator at the inlet of a first cable position in a slot in the stator core in order there to feed the cable into the slot in the stator core, a second cable feeder is placed by its manipulator at the outlet from this first cable position in order to pull the cable axially through the slot in the stator core, the manipulators of the second cable feeder and of a third cable feeder, separately or jointly, thereafter forming with their cable feeders a desired coil arch before the third cable feeder is applied by its manipulator at the inlet of the next cable position in a winding slot in the stator core in order to feed the cable into the stator core there, and a fourth cable feeder is placed by

its manipulator at the outlet from said next cable position in order to pull the cable axially through the stator core, whereupon the desired coil arch is again formed and the winding process is continued at the next cable position in a winding slot in the stator core, etc.

24. A method according to claim 23, **characterized** in that the manipulators are controlled to form, with their cable feeders, coil arches with a mushroom-like geometrical shape in order to increase the radius of curvature in the arches.

25. A method according to claim 23 or 24, **characterized** in that the manipulators are controlled to carry out long winding stages in order to lay cable, with their cable feeders, in large, temporary coil arches, which serve as intermediate storage for the cable during the winding.

26. A method according to any of claims 22 to 25, **characterized** in that at least two unbroken winding turns are wound from a continuous cable length.

27. Cable for winding in an electric machine comprising at least one laminated core, **characterized** in that the same comprises at least two semiconductive layers with intermediate solid insulation to enclose the electric field.

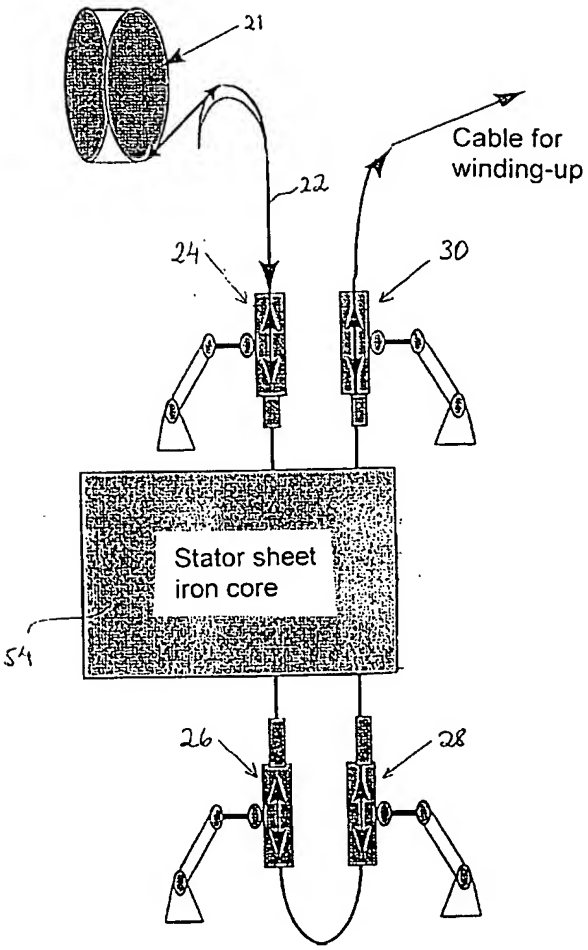
21
Cable for
winding-up
22
24
30
Stator sheet
iron core
54
26
28

Fig. 1

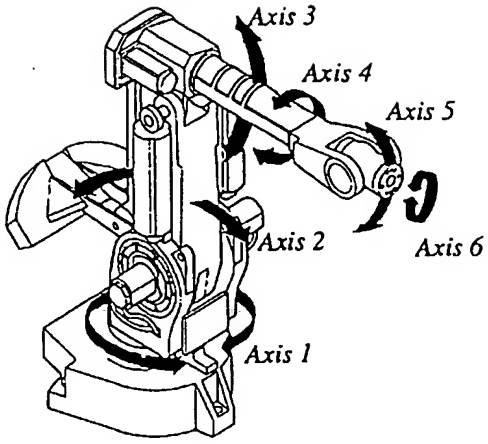

Fig. 2

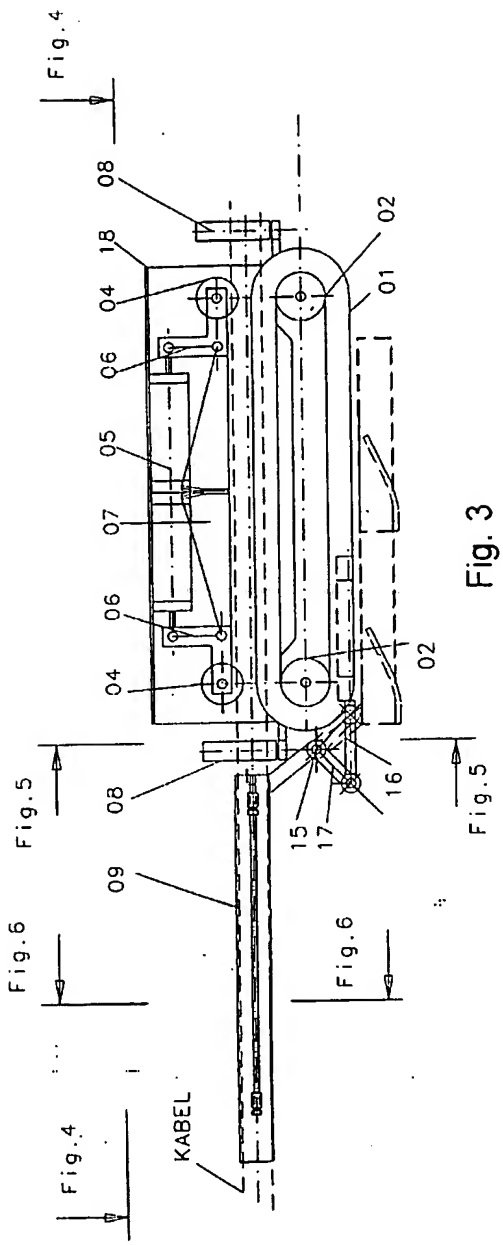
Fig.4
08
18
04
06
05
07
06
04
02
01
02
08
16
15
17
Fig.5
Fig.5
09
Fig.6
Fig.6
KABEL
Fig.4

Fig. 3

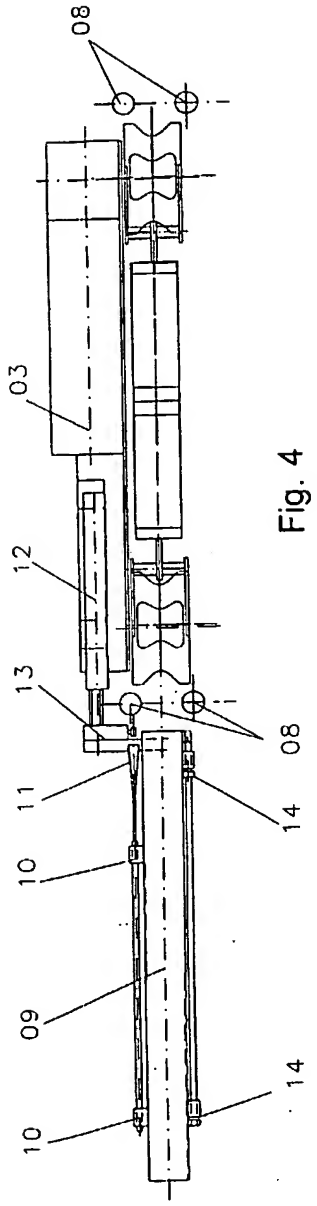

Fig. 4

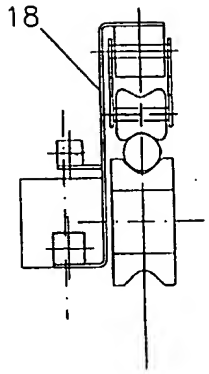

Fig. 5

Guiding tube in opened position

Fig. 6

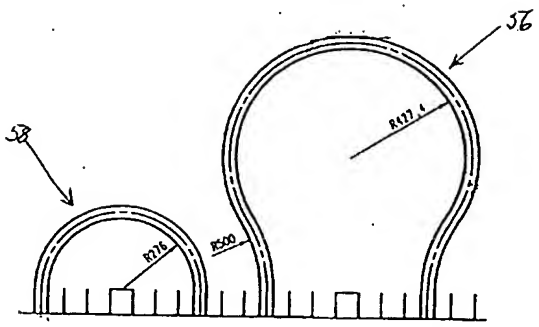

Fig. 7

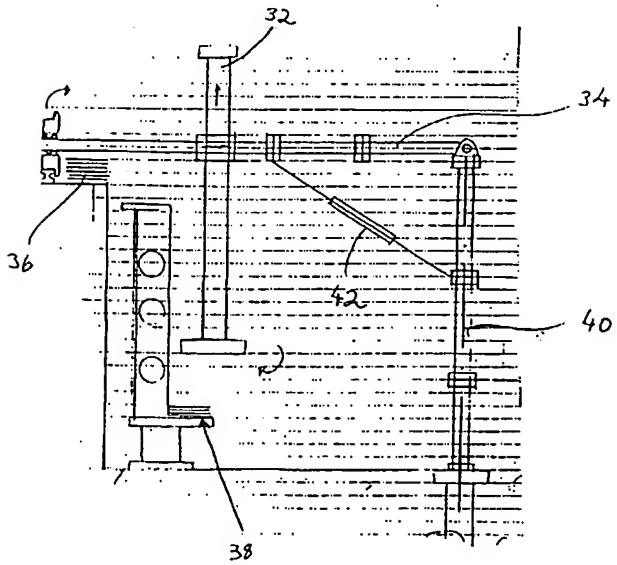

Fig. 8

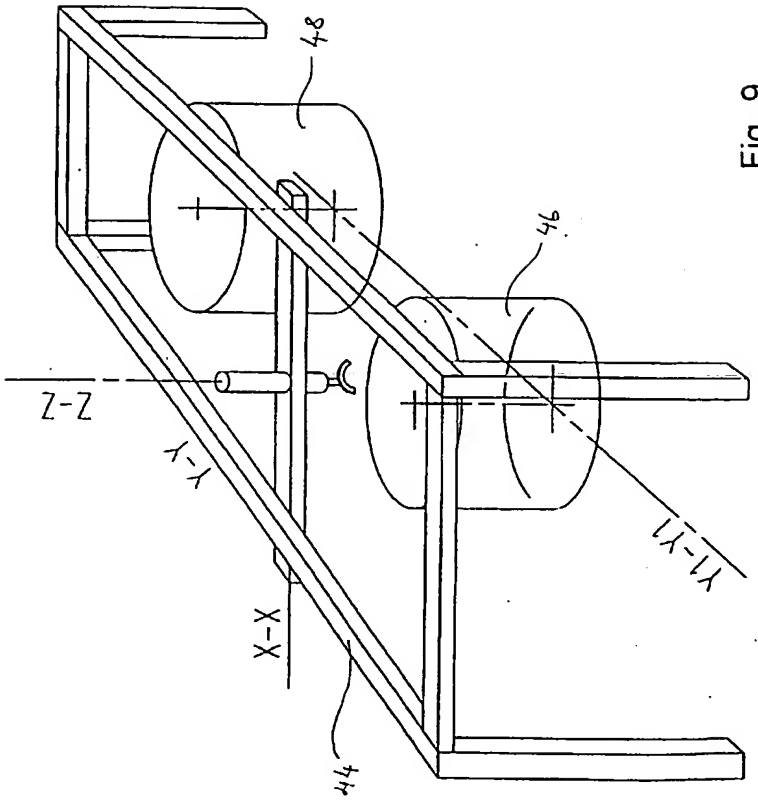

Fig. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/01070

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G05B 19/418, B65H 51/14
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B65H, G05B, H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9834331 A1 (ASEA BROWN BOVERI AB), 6 August 1998 (06.08.98), page 4, line 15 - line 28, figure 5, details 61,62,A,B,S	1,22
Y		2-8,19
	--	
Y	US 5109598 A (KOCH), 5 May 1992 (05.05.92), column 4, line 12 - line 34; column 5, line 65 - line 68, figures 1-2, abstract	2-3,5-8,19
	--	
Y	US 4508251 A (HARADA ET AL), 2 April 1985 (02.04.85), column 2, line 50 - line 53	4
	--	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" ether document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 August 2000	07 -09- 2000
Name and mailing address of the ISA/ Swedish Patent Office, Box 5055, S-102 42 STOCKHOLM, Facsimile No. +46 8 666 02 86	Authorized officer: Teija Kurki / MRo, Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/01070

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5692859 A (DICKSON ET AL), 2 December 1997 (02.12.97)	1-8
A	US 5533658 A (BENEDICT ET AL), 9 July 1996 (09.07.96)	1-8
A	WO 9820602 A1 (ASEA BROVN BOVERI AB), 14 May 1998 (14.05.98)	
A	EP 0185788 A1 (AUDI AG), 2 July 1986 (02.07.86)	
A	US 5586384 A (NEWMAN), 24 December 1996 (24.12.96)	
A	EP 0277358 A2 (WESTECH GEAR CORPORATION), 10 Sept 1982 (10.09.82)	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE00/01070

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).:

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see extra sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims: it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE00/01070

I. Claims 1-26 relate to equipment and to a method for preparation of a winding to an electric cable in an electric machine, which includes a sheet iron core.

II. Claim 27 relates to a cable for winding in an electric machine and which cable includes a sheet iron core.

The common special technical feature of inventions I and II, namely an electric machine with a sheet iron core, is not novel. The groups I and II are not so linked as to form a single general inventive concept. Therefore the unity of invention is lacking.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/SE 00/01070

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9834331 A1	06/08/98	AU 1949897 A	22/09/97
		AU 5892298 A	25/08/98
		BR 9707910 A	27/07/99
		EP 0885469 A	23/12/98
		SE 508544 C	12/10/98
		SE 9700364 A	04/08/98
US 5109598 A	05/05/92	DE 59007328 D	00/00/00
		EP 0423443 A,B	24/04/91
		JP 2904440 B	14/06/99
		JP 3179616 A	05/08/91
US 4508251 A	02/04/85	NONE	
US 5692859 A	02/12/97	GB 2293156 A	20/03/96
		GB 9418469 D	00/00/00
		GB 9518823 D	00/00/00
US 5533658 A	09/07/96	WO 9615061 A	23/05/96
WO 9820602 A1	14/05/98	AU 4973197 A	29/05/98
		EP 0935842 A	18/08/99
		SE 9604025 A	05/05/98
EP 0185788 A1	02/07/86	DE 3473698 D	00/00/00
US 5586384 A	24/12/96	NONE	
EP 0277358 A2	10/09/82	DE 3279244 D	00/00/00
		EP 0084080 A,B	27/07/83
		JP 58123306 A	22/07/83
		US 4469267 A	04/09/84